Catalyst Measurement

Version 2017-05-08

Color Coding Legend				
Data Entry Cell	Calculated Cell	Percent Difference	Area of Concern	Instrument Calibration Out of Range

Engine Family	HHSNX.196A21
VIN/Serial No.	LWGPCML21HA065293
Task Directive	TD 2, Opt. 2
Entry Number	9AR-0277756-3
Inspection Number	20170620-1200-01
Catalyst Inspection Date	6/20/2017
Certificate Catalyst Manufacturer	xxxxx
Certificate Catalyst Part Number	xxxxx
Observed Catalyst Markings	"C [obscured by welding] GF13E3", "[obscured by welding] 0329"

Daily Calibration Results

Instrument Used	Starrett Calipers (SN: 04231713)
Date of Last Simco Calibration (must be < 1 year)	5/2/2017

	End Rod Result	Accuracy (mm)
25 mm End Rod	24.99	0.01
50 mm End Rod	50.00	0
75 mm End Rod	74.99	0.01

	1st Measured Value (mm)	2nd Measured Value (mm)	3rd Measured Value (mm)	4th Measured Value (mm)	Calculated Average Value (mm)	Percent Difference	Certificate Values
Diameter: outside of exhaust piping	Not Measurable	Not Measurable	Not Measurable	Not Measurable	--		
Diameter: outside of catalyst casing	32.0	32.3	31.9	31.9	32.00	--	Not Reported
Diameter: inside of catalyst casing (catalyst diameter)	29.98	29.85	29.29	29.79	29.73	--	xxxxx
Length: exhaust piping	Not Measurable	Not Measurable	Not Measurable	Not Measurable	--		
Length: catalyst casing	34.98	34.97	34.98	34.98	34.98	--	Not Reported
Length: catalyst material	Not Measurable	Not Measurable	Not Measurable	Not Measurable	34.98	--	xxxxx
Inset: catalyst casing (side 1)	Not Measurable	Not Measurable	Not Measurable	Not Measurable	--		
Inset: catalyst casing (side 2)	Not Measurable	Not Measurable	Not Measurable	Not Measurable	--		
Inset: catalyst substrate (side 1)	0.00	0.00	0.00	0.00	0.00		
Inset: catalyst substrate (side 2)	0.00	0.00	0.00	0.00	0.00		
Counted cells (total)	331				volume cc	24.28	--	Not Reported
Avg. inside diameter of casing (in)	1.17				cells/in^2	307.67	xxxxxx	xxxxx

Comments	None
Areas of Concern	None
Photo Used for Counts	DSCN7749_CellCount
Inspector:	Cassidy Owen
ERG Reviewer:	Brent Ruminski
Report Date:	6/23/2017

Honeycomb Catalyst Precious Metals Analysis

Version 2017-05-08

Legend

Data Entry Cell	Result Calculation	Instrument Calibration Out of	LOD - limit of detection

Engine Family	HHSNX.196A21
VIN/Serial No.	LWGPCML21HA065293
Task Directive	TD 2, Opt. 2
Entry Number	9AR-0277756-3
Inspection Number	20170620-1200-02
Catalyst Inspection Date	6/21/2017
Certificate Catalyst Manufacturer	xxxxxx
Certificate Catalyst Part Number	xxxxxx
Observed Catalyst Markings	"C [obscured by welding] GF13E3", "[obscured by welding] 0329"

Instrument Used	X-5000 (S/N: 202212)
Calibration Curve Name	Metallic Curve 2016-01-19
Check Standard ID	Ledoux-11

Daily Check Standard Results

	Measured Value (% concentration)	Measured Value (ppm)	Known Concentration Value (ppm)	Percent Difference (Measured vs. Known Value)	Control Charting Checks
Pt	0.227	2,265	2,021	12.07%	OK
Pd	1.230	12,298	12,474	-1.41%	OK
Rh	0.119	1,194	1,192	0.17%	OK

Measured Precious Metals Concentrations with X5000

	Measured Value (% concentration, by weight)	x-5000 LOD (% Concentration by weight)	Measured Value (ppm)	x-5000 LOD (ppm)
Pt	0.0534	0.0028	534	28
Pd	1.1968	0.0111	11,968	111
Rh	0.1323	0.0021	1,323	21
Ce	42.0200	0.3800	420,200	3,800
Zr	7.0200	0.0600	70,200	600

Material Weight Reconciliation

Pre-Extraction/Separation Weights (g)		Post-Extraction/Separation Weights (g)		Mass Balance Calculations Weights (g)		Percent Losses
Weight of Catalyst	53.56	Post Extraction: Weight of Catalyst	49.79	Theoretical PM and Ferrous Metals	3.77	
Empty Glass Vial (w/ lid)	118.81	Post Extraction: Glass Vial (w/ lid, PM, and ferrous metals)	122.49	Extracted PM and Ferrous Metals	3.68	
Empty Glass Vial (w/ lid)	118.81	Post Separation: Glass Vial (w/ lid and ferrous metal only)	122.23	Extracted Ferrous Metals	3.42	
Empty Sample Cup (no lid, no Mylar)	4.19	Sample Cup with PM (no lid or Mylar)	4.44	Extracted PM Sample	0.25	
				Total Material Lost	0.10	2.65%

Drilling Information

Hole 1

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3825	0.4085	0.3935	0.3935	0.3945
Hole Diameter Side 2	0.3685	0.3920	0.3705	0.3760	0.3768
Drill Bit Diameter (in.)	3/8				

Hole 2

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3930	0.3965	0.3790	0.3925	0.3903
Hole Diameter Side 2	0.4250	0.4075	0.4115	0.4065	0.4126
Drill Bit Diameter (in.)	3/8				

Loading Results

	Calculated Extracted Powder Weight Result (g)	Calculated Extracted Powder Weight LOD (+/- g)	Cert Value - Loading (g/L)	Calculated Metals Loading Result (g/L)	Calculated Metals Loading LOD (+/- g/L)	Percent D Loadin Result (%)
Pt	0.00013	+/- 0.00001	xxxxx	0.024	+/- 0.001	--
Pd	0.00299	+/- 0.00003	xxxxx	0.545	+/- 0.005	--
Rh	0.00033	+/- 0.00001	xxxxx	0.060	+/- 0.001	--
Total	**0.00346**	**+/- 0**	**xxxxx**	**0.629**	**+/- 0.007**	**--**

Test Conditions	3 runs, 90 seconds each
Check Standards	The check standard results passed all daily control charting checks.
Comments:	- Two holes were drilled to try and obtain sufficient amount of PM washcoat sample. However; only 0.25 grams of sample was recovered. ERG estimates that the depth of the sample cup is between 1 mm and 2 mm, which is less than the minimum depth recommended in MSEB's Precious Metals Analysis of Catalyst Washcoat SOP. - Two cuts into the catalyst substrate were made during the catalyst extraction process. The first drilled hole was oriented to miss any of the cuts into the catalyst; however due to the small size of the catalyst, the second drilled hole drilled into a portion of the cut in the catalyst.
Pt Qualifiers	None
Pd Qualifiers	None
Rh Qualifiers	None
Ratios:	xxxxxx
Pt Loading:	
Pd Loading:	#VALUE!
Rh Loading:	#VALUE!
Total Loading:	#VALUE!
Areas of Concern	#VALUE!
Related Photo(s)	DSCN7575 - DSCN7810
Inspector(s):	Cassidy Owen
ERG Reviewer:	Brent Ruminski
Report Date:	6/23/2017

Honeycomb Catalyst Precious Metals Analysis

Version 2017-05-08

Legend			
Data Entry Cell	Result Calculation	Instrument Calibration Out of	LOD - limit of detection

Engine Family	HHSNX.196A21
VIN/Serial No.	LWGPCML21HA065293
Task Directive	TD 2, Opt. 2
Entry Number	9AR-0277756-3
Inspection Number	20170620-1200-03
Catalyst Inspection Date	6/21/2017
Certificate Catalyst Manufacturer	xxxxx
Certificate Catalyst Part Number	xxxxx
Observed Catalyst Markings	"C [obscured by welding] GF13E3", "[obscured by welding] 0329"

Instrument Used	X-5000 (S/N: 202212)
Calibration Curve Name	Metallic Curve 2016-01-19
Check Standard ID	Ledoux-11

Daily Check Standard Results

	Measured Value (% concentration)	Measured Value (ppm)	Known Concentration Value (ppm)	Percent Difference (Measured vs. Known Value)	Control Charting Checks
Pt	0.233	2,325	2,021	15.04%	OK
Pd	1.247	12,466	12,474	-0.06%	OK
Rh	0.122	1,222	1,192	2.52%	OK

Measured Precious Metals Concentrations with X5000

	Measured Value (% concentration, by weight)	x-5000 LOD (% Concentration by weight)	Measured Value (ppm)	x-5000 LOD (ppm)
Pt	0.0465	0.0024	465	24
Pd	0.9751	0.0091	9,751	91
Rh	0.1085	0.0018	1,085	18
Ce	44.1900	0.4000	441,900	4,000
Zr	5.9000	0.0500	59,000	500

Material Weight Reconciliation

Pre-Extraction/Separation Weights (g)		Post-Extraction/Separation Weights (g)		Mass Balance Calculations Weights (g)		Percent Losses
Weight of Catalyst	53.56	Post Extraction: Weight of Catalyst	49.79	Theoretical PM and Ferrous Metals	3.77	
Empty Glass Vial (w/ lid)	118.81	Post Extraction: Glass Vial (w/ lid, PM, and ferrous metals)	122.49	Extracted PM and Ferrous Metals	3.68	
Empty Glass Vial (w/ lid)	118.81	Post Separation: Glass Vial (w/ lid and ferrous metal only)	122.23	Extracted Ferrous Metals	3.42	
Empty Sample Cup (no lid, no Mylar)	4.19	Sample Cup with PM (no lid or Mylar)	4.44	Extracted PM Sample	0.25	
				Total Material Lost	0.10	2.65%

Drilling Information

Hole 1

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3825	0.4085	0.3935	0.3935	0.3945
Hole Diameter Side 2	0.3685	0.3920	0.3705	0.3760	0.3768
Drill Bit Diameter (in.)	3/8				

Hole 2

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3930	0.3965	0.3790	0.3925	0.3903
Hole Diameter Side 2	0.4250	0.4075	0.4115	0.4065	0.4126
Drill Bit Diameter (in.)	3/8				

Loading Results

	Calculated Extracted Powder Weight Result (g)	Calculated Extracted Powder Weight LOD (+/- g)	Cert Value - Loading (g/L)	Calculated Metals Loading Result (g/L)	Calculated Metals Loading LOD (+/- g/L)	Percent D Loadin Result (%)
Pt	0.00012	+/- 0.00001	xxxxx	0.021	+/- 0.001	--
Pd	0.00244	+/- 0.00002	xxxxx	0.444	+/- 0.004	--
Rh	0.00027	+/- 0	xxxxx	0.049	+/- 0.001	--
Total	**0.00283**	**+/- 0**	**xxxxx**	**0.514**	**+/- 0.006**	**--**

Test Conditions	3 runs, 90 seconds each
Check Standards	The check standard results passed all daily control charting checks.
Comments:	- The catalyst was crushed to extract additional PM sample. This analysis was performed on the PM sample from crushing the catalyst only. The PM sample from crushing was observed to have larger particle size than from drilling the catalyst. - Two cuts into the catalyst substrate were made during the catalyst extraction process. The first drilled hole was oriented to miss any of the cuts into the catalyst; however due to the small size of the catalyst, the second drilled hole drilled into a portion of the cut in the catalyst.
Pt Qualifiers	None
Pd Qualifiers	None
Rh Qualifiers	None
Ratios:	xxxxxx
Pt Loading:	
Pd Loading:	#VALUE!
Rh Loading:	#VALUE!
Total Loading:	#VALUE!
Areas of Concern	#VALUE!
Related Photo(s)	DSCN7575 - DSCN7810
Inspector(s):	Cassidy Owen
ERG Reviewer:	Brent Ruminski
Report Date:	6/23/2017

Honeycomb Catalyst Precious Metals Analysis

Version 2017-05-08

Legend

Data Entry Cell	Result Calculation	Instrument Calibration Out of	LOD - limit of detection

Engine Family	HHSNX.196A21
VIN/Serial No.	LWGPCML21HA065293
Task Directive	TD 2, Opt. 2
Entry Number	9AR-0277756-3
Inspection Number	20170620-1200-04
Catalyst Inspection Date	6/21/2017
Certificate Catalyst Manufacturer	xxxxx
Certificate Catalyst Part Number	xxxxx
Observed Catalyst Markings	"C [obscured by welding] GF13E3", "[obscured by welding] 0329"

Instrument Used	X-5000 (S/N: 202212)
Calibration Curve Name	Metallic Curve 2016-01-19
Check Standard ID	Ledoux-11

Daily Check Standard Results

	Measured Value (% concentration)	Measured Value (ppm)	Known Concentration Value (ppm)	Percent Difference (Measured vs. Known Value)	Control Charting Checks
Pt	0.233	2,325	2,021	15.04%	OK
Pd	1.247	12,466	12,474	-0.06%	OK
Rh	0.122	1,222	1,192	2.52%	OK

Measured Precious Metals Concentrations with X5000

	Measured Value (% concentration, by weight)	x-5000 LOD (% Concentration by weight)	Measured Value (ppm)	x-5000 LOD (ppm)
Pt	0.0631	0.0032	631	32
Pd	1.6488	0.0159	16,488	159
Rh	0.1777	0.0028	1,777	28
Ce	37.3400	0.3700	373,400	3,700
Zr	8.9500	0.0800	89,500	800

Material Weight Reconciliation

Pre-Extraction/Separation Weights (g)		Post-Extraction/Separation Weights (g)		Mass Balance Calculations Weights (g)		Percent Losses
Weight of Catalyst	53.56	Post Extraction: Weight of Catalyst	49.79	Theoretical PM and Ferrous Metals	3.77	
Empty Glass Vial (w/ lid)	118.81	Post Extraction: Glass Vial (w/ lid, PM, and ferrous metals)	122.49	Extracted PM and Ferrous Metals	3.68	
Empty Glass Vial (w/ lid)	118.81	Post Separation: Glass Vial (w/ lid and ferrous metal only)	122.23	Extracted Ferrous Metals	3.42	
Empty Sample Cup (no lid, no Mylar)	4.19	Sample Cup with PM (no lid or Mylar)	4.44	Extracted PM Sample	0.25	
				Total Material Lost	0.10	2.65%

Drilling Information

Hole 1

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3825	0.4085	0.3935	0.3935	0.3945
Hole Diameter Side 2	0.3685	0.3920	0.3705	0.3760	0.3768
Drill Bit Diameter (in.)	3/8				

Hole 2

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3930	0.3965	0.3790	0.3925	0.3903
Hole Diameter Side 2	0.4250	0.4075	0.4115	0.4065	0.4126
Drill Bit Diameter (in.)	3/8				

Loading Results

	Calculated Extracted Powder Weight Result (g)	Calculated Extracted Powder Weight LOD (+/- g)	Cert Value - Loading (g/L)	Calculated Metals Loading Result (g/L)	Calculated Metals Loading LOD (+/- g/L)	Percent D Loadin Result (%)
Pt	0.00016	+/- 0.00001	xxxxx	0.029	+/- 0.001	--
Pd	0.00412	+/- 0.00004	xxxxx	0.751	+/- 0.007	--
Rh	0.00044	+/- 0.00001	xxxxx	0.081	+/- 0.001	--
Total	**0.00472**	**+/- 0.0001**	**xxxxx**	**0.860**	**+/- 0.01**	**--**

Test Conditions	3 runs, 90 seconds each
Check Standards	The check standard results passed all daily control charting checks.
Comments:	- The PM sample from the two drilled holes was combined with the PM sample from crushing. The combined PM sample mass was 0.47 grams and had a depth of approximately 3mm in the sample cup. - Two cuts into the catalyst substrate were made during the catalyst extraction process. The first drilled hole was oriented to miss any of the cuts into the catalyst; however due to the small size of the catalyst, the second drilled hole drilled into a portion of the cut in the catalyst.
Pt Qualifiers	None
Pd Qualifiers	The measured concentration of Pd in the compliance sample (16488 ppm) was outside the x-5000 calibration curve range (70 - 12809 ppm).
Rh Qualifiers	None
Ratios:	xxxxxx
Pt Loading:	
Pd Loading:	#VALUE!
Rh Loading:	#VALUE!
Total Loading:	#VALUE!
Areas of Concern	#VALUE!
Related Photo(s)	DSCN7575 - DSCN7810
Inspector(s):	Cassidy Owen
ERG Reviewer:	Brent Ruminski
Report Date:	6/23/2017

Honeycomb Catalyst Precious Metals Analysis

Version 2017-05-08

Legend

Data Entry Cell	Result Calculation	Instrument Calibration Out of	LOD - limit of detection

Engine Family	HHSNX.196A21
VIN/Serial No.	LWGPCML21HA065293
Task Directive	TD 2, Opt. 2
Entry Number	9AR-0277756-3
Inspection Number	20170620-1200-05
Catalyst Inspection Date	6/22/2017
Certificate Catalyst Manufacturer	xxxxx
Certificate Catalyst Part Number	xxxxx
Observed Catalyst Markings	"C [obscured by welding] GF13E3", "[obscured by welding] 0329"

Instrument Used	X-5000 (S/N: 202212)
Calibration Curve Name	Metallic Curve 2016-01-19
Check Standard ID	Ledoux-11

Daily Check Standard Results

	Measured Value (% concentration)	Measured Value (ppm)	Known Concentration Value (ppm)	Percent Difference (Measured vs. Known Value)	Control Charting Checks
Pt	0.226	2,264	2,021	12.02%	OK
Pd	1.257	12,570	12,474	0.77%	OK
Rh	0.123	1,231	1,192	3.27%	OK

Measured Precious Metals Concentrations with X5000

	Measured Value (% concentration, by weight)	x-5000 LOD (% Concentration by weight)	Measured Value (ppm)	x-5000 LOD (ppm)
Pt	0.0619	0.0033	619	33
Pd	1.6708	0.0163	16,708	163
Rh	0.1848	0.0029	1,848	29
Ce	41.3300	0.4000	413,300	4,000
Zr	9.0300	0.0800	90,300	800

Material Weight Reconciliation

Pre-Extraction/Separation Weights (g)		Post-Extraction/Separation Weights (g)		Mass Balance Calculations Weights (g)		Percent Losses
Weight of Catalyst	53.56	Post Extraction: Weight of Catalyst	49.79	Theoretical PM and Ferrous Metals	3.77	
Empty Glass Vial (w/ lid)	118.81	Post Extraction: Glass Vial (w/ lid, PM, and ferrous metals)	122.49	Extracted PM and Ferrous Metals	3.68	
Empty Glass Vial (w/ lid)	118.81	Post Separation: Glass Vial (w/ lid and ferrous metal only)	122.23	Extracted Ferrous Metals	3.42	
Empty Sample Cup (no lid, no Mylar)	4.19	Sample Cup with PM (no lid or Mylar)	4.44	Extracted PM Sample	0.25	
				Total Material Lost	0.10	2.65%

Drilling Information

Hole 1

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3825	0.4085	0.3935	0.3935	0.3945
Hole Diameter Side 2	0.3685	0.3920	0.3705	0.3760	0.3768
Drill Bit Diameter (in.)	3/8				

Hole 2

	1st Measured Value (inches)	1st Measured Value (inches)	3rd Measured Value (inches)	4th Measured Value (inches)	Calculated Average Value (inches)
Hole Diameter Side 1	0.3930	0.3965	0.3790	0.3925	0.3903
Hole Diameter Side 2	0.4250	0.4075	0.4115	0.4065	0.4126
Drill Bit Diameter (in.)	3/8				

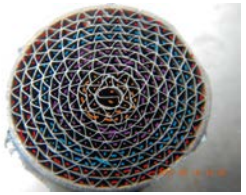
Loading Results

	Calculated Extracted Powder Weight Result (g)	Calculated Extracted Powder Weight LOD (+/- g)	Cert Value - Loading (g/L)	Calculated Metals Loading Result (g/L)	Calculated Metals Loading LOD (+/- g/L)	Percent D Loadin Result (%)
Pt	0.00015	+/- 0.00001	xxxxx	0.028	+/- 0.002	--
Pd	0.00418	+/- 0.00004	xxxxx	0.761	+/- 0.007	--
Rh	0.00046	+/- 0.00001	xxxxx	0.084	+/- 0.001	--
Total	**0.00479**	**+/- 0.0001**	**xxxxx**	**0.873**	**+/- 0.01**	**--**

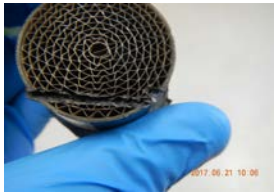
Test Conditions	3 runs, 90 seconds each
Check Standards	The check standard results passed all daily control charting checks.
Comments:	- The catalyst was again crushed to extract more PM sample and combined with the previously combined sample in the cup. The combined PM sample mass was 0.59 grams and had a depth of approximately 3mm in the sample cup. - Two cuts into the catalyst substrate were made during the catalyst extraction process. The first drilled hole was oriented to miss any of the cuts into the catalyst; however due to the small size of the catalyst, the second drilled hole drilled into a portion of the cut in the catalyst.
Pt Qualifiers	None
Pd Qualifiers	The measured concentration of Pd in the compliance sample (16708 ppm) was outside the x-5000 calibration curve range (70 - 12809 ppm).
Rh Qualifiers	None
Ratios:	xxxxxx
Pt Loading:	
Pd Loading:	#VALUE!
Rh Loading:	#VALUE!
Total Loading:	#VALUE!
Areas of Concern	#VALUE!
Related Photo(s)	DSCN7575 - DSCN7810
Inspector(s):	Cassidy Owen
ERG Reviewer:	Brent Ruminski
Report Date:	6/23/2017

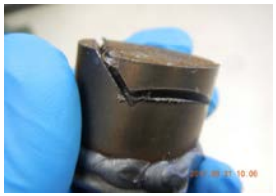
Photograph of Catalyst Part Number

Cell Count Photo

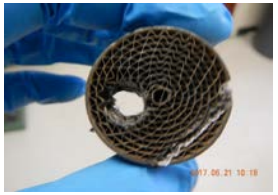


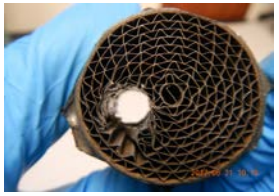
Photographs of Cuts into Catalyst





Drilled Hole Photo





Crushing Photographs